A Thesis Title

by

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Submitted to the Dept. of Earth, Atmospheric and Planetary Sciences
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Abstract

In this thesis, I designed and implemented a compiler which performs optimizations that reduce the number of low-level floating point operations necessary for a specific task; this involves the optimization of chains of floating point operations as well as the implementation of a "fixed" point data type that allows some floating point operations to simulated with integer arithmetic. The source language of the compiler is a subset of C, and the destination language is assembly language for a micro-floating point CPU. An instruction-level simulator of the CPU was written to allow testing of the code. A series of test pieces of codes was compiled, both with and without optimization, to determine how effective these optimizations were.

Thesis Supervisor: Glenn R. Flierl
Title: Professor of Oceanography

Acknowledgments

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The numerical scheme chosen was a second-order Runge-Kutta method with a long track record in trajectory modeling [Petterssen, 1940]. The velocity at a given timestep is taken to be the average of the velocity at the initial position and the velocity at the first-guess position after one timestep.

The first guess position $\vec{P}'(t + \Delta t)$ is

$$\vec{P}'(t + \Delta t) = \vec{P}(t) + \vec{V}(\vec{P}, t)\Delta t \qquad (2.1)$$

and the final position $\vec{P}(t + \Delta t)$ is

$$\vec{P}(t + \Delta t) = \vec{P}(t) + \frac{1}{2}\left[\vec{V}(\vec{P}, t) + \vec{V}(\vec{P}', t + \Delta t)\right]\Delta t \qquad (2.2)$$

where $\vec{P}$ is a position vector with latitude and longitude components, and $\vec{V}$ a velocity vector with u and v wind speeds [Draxler and Hess, 1997]. This integration method is used by HYSPLIT and a number of other trajectory models, including FLEXPART, LAGRANTO, and STILT [Stein et al., 2015] [Bowman et al., 2013].

For trajectories calculated from interpolated gridded wind velocities, higher order integration schemes do not add precision [Draxler and Hess, 1997].

2.3 Timestep

The timestep for integration was three minutes, with the timestep throughout the trajectory. To save computation, HYSPLIT uses a dynamic timestep, varying from one minute to one hour, computed to satisfy

$$U_{max}[\text{grid-units min}^{-1}]\Delta t[\text{min}] < 0.75[\text{grid-units}] \tag{2.3}$$

[Draxler and Hess, 1997]. This ensures that the parcel does not blow past any grid squares, which would reduce the accuracy of the calculation.

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